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MARTIN MARIETTA
MANNED SPACE SYSTEMS

National Aeronautics and Space Administration
Marshall Space Flight Center
Michoud Assembly Facility

Contract NAS8-36200
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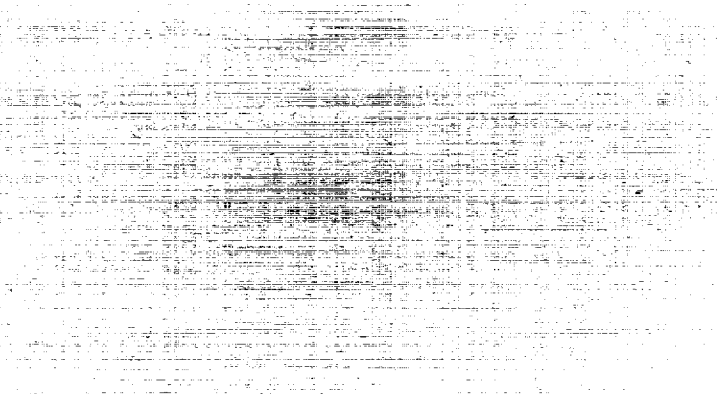
ET Project - Computer Integrated Laboratory Operations (CILO)

October 30, 1992



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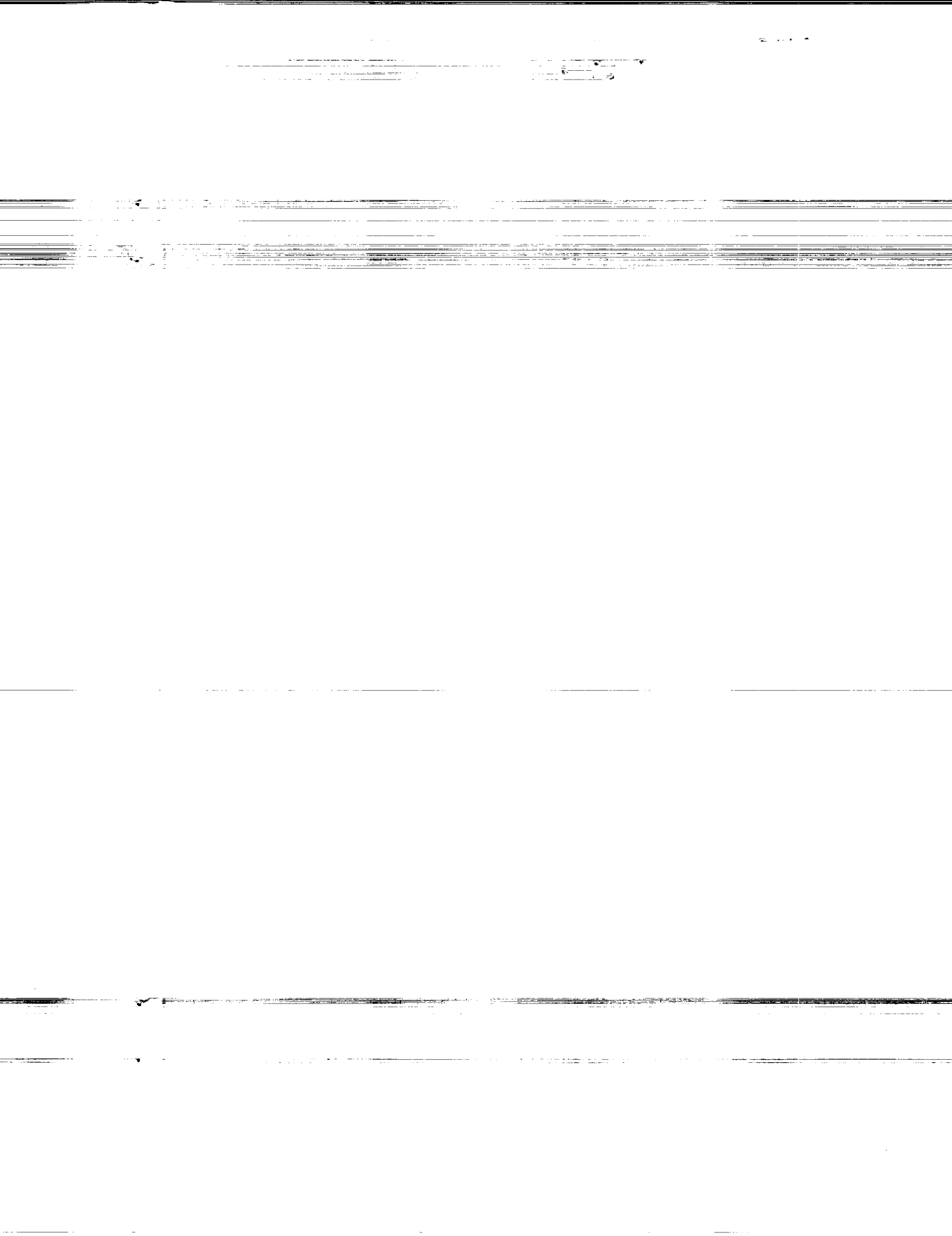

MARTIN MARIETTA
MANNED SPACE SYSTEMS

ANNUAL REPORT - FY92

COMPUTER INTEGRATED LABORATORY OPERATIONS

(CILO)

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ACKNOWLEDGEMENTS

Successes achieved by this automation project during the past year were attainable only through the enthusiastic participation of the entire CILO Project Matrix Team, other Manned Space Systems personnel, and NASA Technical Staff members at both the Michoud Assembly Facility and Marshall Space Flight Center. Their efforts are appreciated.

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I. EXECUTIVE SUMMARY

During Fiscal Year 1992 the efforts of the Computer Integrated Laboratory Operations (CILO) Matrix Team were focused in four key areas. These major areas of effort were enhancement of mainframe application performance and capability, enhancement of Laboratory Information Management Systems (LIMS) performance and capabilities, development and implementation of paperless and automated systems in support of the reorganized laboratory and laboratory management, and development of automation technology in support of MAF organizations. Additionally, CILO personnel participated in the development of paperless systems technology at MSFC and provided leadership for and input to the International VM-LIMS User's Group. On February 20, 1992, John W. Spencer was designated CILO project lead by Donald J. Hazelwood, who assumed the duties of Chief, Computer and Administrative Laboratory Services in the newly organized Technology Laboratories Department of Technical Operations.

Major accomplishments in each of the key areas are summarized below.

System Performance

The performance and disk storage capacity of the dedicated CILO IBM 9375 Minimainframe have steadily declined over the past few years as additional capabilities and users have been added to the system and funds for necessary upgrades. As a result significant emphasis was placed on improved system performance and disk capacity through software upgrades, redesign of existing user applications, automation of critical system functions, and the judicious purchase and application of user support software. Several of these efforts are fully described in this report.

Even after the successful implementation of these methods, the mainframe is operating at maximum capacity and significant improvement of system response time is required. A request for upgrade of the system hardware and storage capacity was submitted again for FY93. System performance and capacity remain the most critical challenge facing the CILO team. Future development activities will be severely limited in the absence of the requested hardware upgrades.

Laboratory Information Management System

Several important LIMS activities were accomplished during the reporting period. The LIMS software was upgraded to a more efficient and user-friendly version. Over 1200 LIMS procedure changes were made to make user interaction with the system easier and more efficient. LIMS was expanded to incorporate job tracking and statusing for all new laboratory organizations. LIMS was evaluated for future laboratory system interface with MRPII (COPICS) and Open Plan.

Laboratory Paperless Systems

Several applications were developed to support laboratory users and laboratory management during FY92. Many LAN based applications were developed and implemented to enhance the productivity of laboratory users. These include:

- Laboratory Action Item Tracker
- Laboratory Failure Analysis Tracker
- Laboratory RFF Tracker
- Laboratory Administration Area
- Laboratory Document Control Facility

Two mainframe applications, Purchase Requisition Tracker and Laboratory Budget Tracker, were also implemented and the laboratory planning and control expert system, ASK ANDY was enhanced. A complete description of these applications is provided in this document.

Automation Technology

CILO personnel continue to support the development and implementation of automation technology at MAF. CILO provided extensive technical support to the development and implementation of the Weld Acceptance Data Evaluation System (WADES). Several high return on investment automation initiatives were identified for development by CILO personnel. A discussion of WADES progress and future initiatives can be found later in this report.

Future Activities

The CILO Matrix Team will continue to provide expert support for automation technology at MAF. Laboratory support activities will include a continued focus on improvement of mainframe performance and capacity, expansion of LIMS technology, implementation of official laboratory reporting via LIMS routines, and refinement and expansion of laboratory paperless systems among others. High return on investment automation initiatives identified during FY92 will be aggressively pursued and implemented during FY93.

II. PURPOSE

The original goal of the Computer Integrated Laboratory Operations Project (CILO) was to study, design, develop, and implement applications that facilitate use of integrated computer systems serving the Michoud Assembly Facility (MAF). Standardized networking technologies were to be applied to enable integrated resource sharing in support of the manufacture of External Tanks. The resulting network would be engineered to provide all media, high-speed communications between all laboratories and laboratory interfaced processes at MAF and NASA MSFC.

III. BACKGROUND

The Quality Evaluation Laboratory was selected in 1986 as the pilot laboratory for the CILO project. This laboratory had been responsible for conducting all raw material, in-line process, and final process tests at MAF. Based upon these assigned testing responsibilities, the Quality Laboratory had documented and maintained process and production control test results and all quality certifications since 1974. There was, however, no common database or coordination of existing databases such as between failure effects analyses, basic laboratory reference data, RAP testing, and process control test results. In order to create a common Quality Laboratory database for rapid access to and evaluation of all quality acceptance test criteria and failure effects analysis data, it was necessary to acquire a minicomputer system incorporating an interactive software package. This system, termed the Laboratory Host Data System (LHDS) was envisioned as capable of phased expansion and refinement to the point where it would support all MAF laboratory activities and certain discrete NASA/MSFC laboratory operations. The installation of routine upgrades was viewed as the probable expansion path and these upgrades would be purely need-driven. System refinements, however, would likely occur on a more deliberately incremental basis. As an example, the first expert systems to be developed would be specification-driven and fielded selectively on a limited number of work stations. More extensive fielding of these systems would follow before development of advanced and sophisticated systems such as those which would afford true "hand-holding" support for integrated failure-effects analysis.

When the idea of developing the Laboratory Network Test Bed (LNTB) under the auspices of the CILO project was originally conceived, there were no other developmental activities addressing the application of networking to the MAF production environment. Moreover, the Test Operations Engineering (TOE) and Quality Laboratories had the most established base for a study of this type. The TOE Laboratories had a well established production support and software development laboratory equipped with a good complement of mini and micro computer systems. The TOE Laboratories also offered a solid operations and programming base by way of assigned Management Information Systems (MIS) personnel. The Quality Laboratories possessed a laboratory environment that was in transition from a non-integrated systems operating mode to an integrated operation with a specific focus on large scale database applications (i.e., CILO, Phase I).

The prototype LHDS, an IBM 4361 with basic system software, was acquired from the vendor on a "loaner" basis and installed in the last quarter of FY87. The first version of the Axiom Systems product VM/LIMS was installed shortly thereafter and tested successfully with direct support of the vendor. When the new technology IBM super minimainframe 9370 was delivered and installed in early FY88, it was found that this machine was not totally compatible with the older technology 4361. Extensive reprogramming and hardware "tuning" was necessary in order to get the system to function as intended. When this was accomplished to the satisfaction of the System Administrator, emphasis was placed upon acquiring, installing, and testing all associated peripherals through the mainframe, training of the laboratory staff, developing the database, and building user confidence.

In FY89, the LHDS, a 9370 Model 40 was formally upgraded to Model 60 configuration, the existing lease of all "on-site" CILO system equipment was purchased, and all components were tagged with NASA control numbers. Database development for the Failure Analysis, Surface Science, Metallurgy, and Receiving Inspection Laboratory was accomplished ahead of schedule and our interface with the Materials and Processes Technical Information System (MAPTIS) at MSFC was successfully reestablished via a new 19.2 KBS dedicated line. "Esk Andy," our first expert system (ES) application, was implemented and expanded with two ES subsets. In Task B, Laboratory Networking, the intensive training of employees paid off by enabling early completion of an as-built design for a TOE Baseband LAN and associated test plan. A two-stage plan for migrating the TOE LAN to the Open System Interconnect (OSI) Network Protocol Model was also completed and work continued to ensure full connectivity of the MAF laboratories LAN to the new MAF Broadband Local Area Network.

The major emphasis during FY90 was to extract the best possible performance out of the existing IBM 9375 hardware and software, connect new peripheral equipment, conduct the requisite training, and refine and expand LIMS to better support the needs of the laboratories and laboratory customers. Additional efforts included the development and implementation of paperless productivity applications and the implementation of automation technology at MAF.

The primary focus of activities in FY91 was again on LHDS performance issues with emphasis on improved user response time and system disk storage capacity. Urgent requests for system hardware upgrade were not approved and no hardware upgrades have occurred. Additional efforts in FY91 included system maintenance, user training, and expanded LIMS support for laboratory procedures. Significant effort was placed in a feasibility study of automation technology, including a robotic delivery vehicle, LAN based productivity applications, and laboratory robotics. The robot delivery vehicle was deferred indefinitely by management as a result of funding constraints. The LAN based application study was successfully completed under ESO 89876. This study provided the foundation for significant development activity in FY92. A specification for a laboratory robot was prepared and submitted. The requested robot has not been delivered.

IV. ACTIVITIES

Activities of the CILO Project Matrix Team during FY92 were diverse. CILO activities have been divided into administrative and development categories. A thorough description of each category appears below.

Administrative activities included routine maintenance of CILO hardware and software applications, training of personnel in laboratory computer systems utilization, and departmental support activities. Significant effort was expended in routine maintenance and administration of hardware and applications. These activities included:

- Daily, weekly, and monthly system backups
- LAN account administration
- Application administration
- Mainframe security administration

Training and on-line support of CILO users was performed as necessary to maintain and expand a computer literate user base. Training activities included:

- New user training
- CILO/LIMS training
- On-line/on call training support
- Applications training interface

CILO personnel provided extensive administrative support for the Technology Laboratories Dept. 435X. Administrative duties included:

- Custodial control of all laboratory computer systems
- Acquisition and allocation of all laboratory computer systems
- Hardware and software configuration maintenance of all laboratory computer systems.

While these activities appear somewhat mundane, they formed the baseline of CILO effort and occupied a significant portion of the time allotted to the project team. Administrative and maintenance activities are ongoing efforts that will continue throughout FY93. Since the primary interest of laboratory automation is development and implementation, no further discussion of administrative activities will be provided in this report.

Development activities included all efforts to enhance capability through improvement of existing applications and implementation of new applications. The team worked extensively in the development category of activities. Significant effort was expended to enhance mainframe performance and disk capacity. Laboratory Information Management System (LIMS) capability was expanded and enhanced. Many new paperless productivity applications were developed, tested, and implemented. CILO personnel provided extensive technical expertise and hardware support to MAF automation initiatives. Two significant hardware improvements were accomplished and two automation related meetings were attended. The later involved participation in an international LIMS forum and presentation of a seminar on paperless technology to representatives from NASA/MSFC.

A complete description of the development activities and accomplishments of the CILO Project Matrix Team is provided in this report. Accomplishments are delineated by major area of development activity. Figure 1 depicts the new CILO Project Matrix Team format.

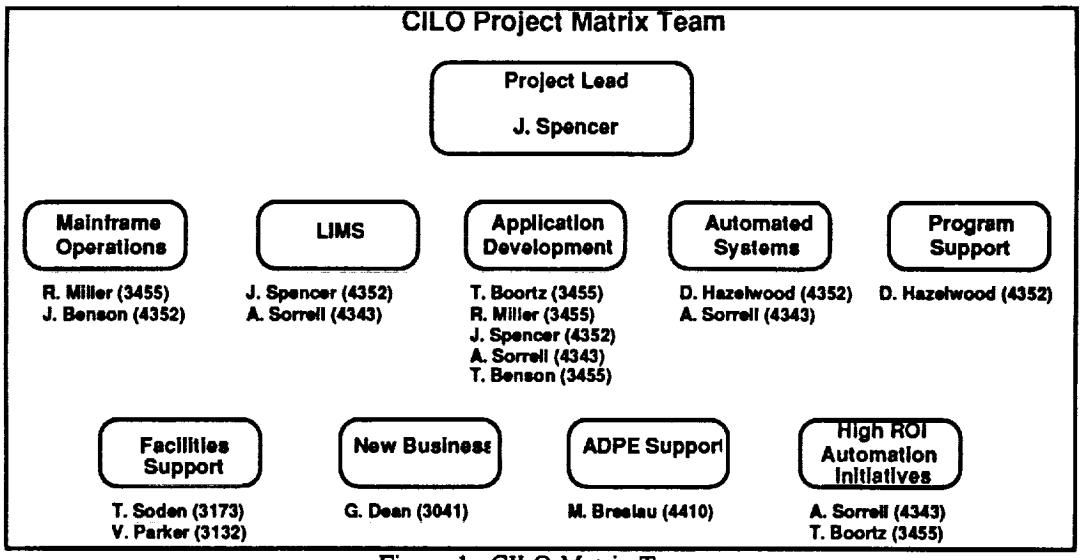

Figure 1. CILO Matrix Team

Mainframe Performance and Capacity Enhancement

The CILO LHDS IBM 9375 Model 60 Mini-mainframe has been continuously expanded to support a variety of high impact applications for laboratory professionals and laboratory customers over the past three years. Many new users and applications have been added to the system. LIMS support for laboratory activities has steadily increased during this period. Most recently, LIMS was expanded to support job tracking for approximately 40 new laboratory professionals (Dept. 4351). Additionally, the LHDS has been required to support a larger group of lab customers and a more diverse set of technical applications. These expansion requirements may increase in FY93. Figure 2 shows the progression of LHDS users to date.

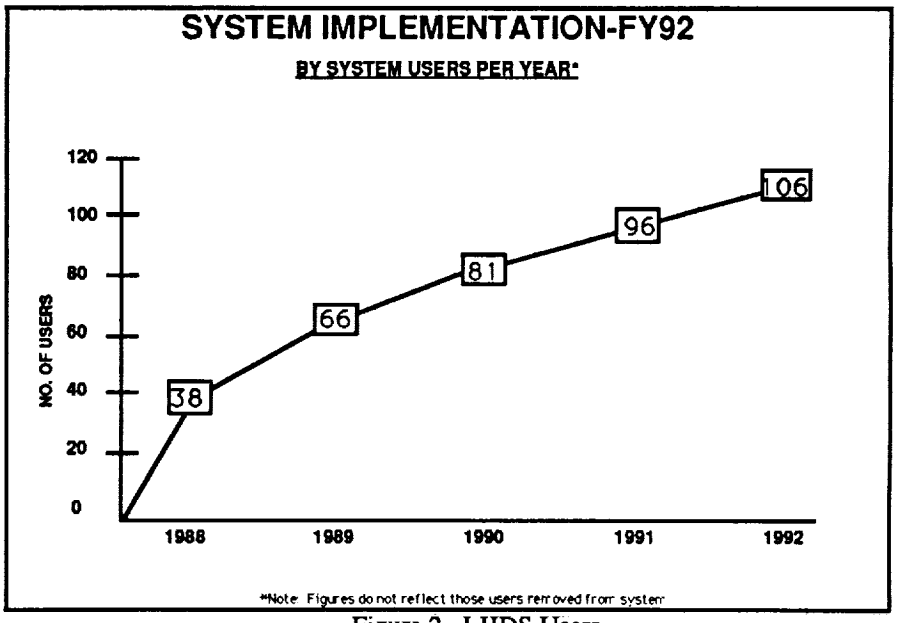

Figure 2. LHDS Users

No concurrent upgrade of existing hardware has accompanied the tremendous additional burden placed on the LHDS. User response time and reserve storage capacity have continued to deteriorate as a result of increased system demand and failure to upgrade. Disk capacity is especially troublesome. As of the generation of this report LHDS disk capacity was 92 percent utilized. Until additional disk capacity is obtained, only limited support of new users will be possible and further implementation of software upgrades will be significantly delayed. Obviously, system performance and system storage capacity continue to be critical issues.

Accordingly, significant emphasis was placed on enhancing system performance and capacity during FY92. Accomplishments in this area were realized through the upgrade of existing software, redesign of existing user applications, automation of critical maintenance activities, and the judicious purchase and implementation of new user support software. Each of these activities is discussed in detail below.

Disk Space Reclamation: A major restructuring of user disk space was conducted. User space for routine lab users was reduced by 75 percent. The disk space reclaimed was devoted to a restructuring of LIMS database tables and the upgrade of the LIMS software to version 2.7.1. This resulted indirectly in slightly increased performance due to more efficient access of LIMS data tables. Enhancements due to the LIMS upgrade are presented in the LIMS section of this report.

Automated Database Maintenance: Significant programming effort was expended to completely automate the routine reorganization of the LIMS database tables. Reorganization of these tables is critical because it efficiently organizes the disk space used for LIMS and makes data access faster (reduces user response time). Automation of this critical maintenance activity ensures maximized database efficiency at current usage parameters and enhances the productivity of CILO maintenance activities.

LIMS Upgrade: LIMS software was upgraded from version 2.6.5 to version 2.7.1. The new version of LIMS provides more efficient use of dedicated disk space and a more efficient user interface. LIMS 2.7.1 provides more user features while requiring fewer screen operations. As a result some disk capacity was saved and apparent user response time was improved. Several enhancements to user interface were also realized as a result of this upgrade. They will be discussed in detail in the LIMS section of this report.

New User Interface Software: A new mainframe software package was acquired and implemented. This software, XMenu, provided for the development of efficient user interfaces for various existing CILO applications including LIMS, budget tracking, PR tracking, and others. Existing data handling and acquisition techniques made use of very powerful but inefficient mainframe software. Applications developed using the new software provided rapid access to data for applications that did not require the existing full featured mainframe software. XMenu user interfaces developed to date indicate that a 50 percent reduction in data access time for simple applications is possible. This product will be used to upgrade many existing applications during the next fiscal year.

New AP Direct Software: Through an analysis of new vendor support software, we identified a product, AP Direct, that significantly reduces laboratory user interaction with LIMS. This product allows a lab user to enter data at a DOS workstation and automatically formats the data and enters it into LIMS as a background activity. This means that lab users can interact with LIMS at PC workstation speeds rather than mainframe speeds and effectively reduces user response time. The product also provides the capability to connect instruments directly to LIMS thus completely eliminating the need for manual data entry. Acquisition of this product would increase laboratory data entry productivity by at least one order of magnitude. This software has been requested for 1QFY93 delivery.

New Selective Archiving and Retrieval (SAR) Software: The VM-LIMS SAR product was purchased and installed. This product allows the archival of LIMS data not required on a routine basis. It also removes outdated versions of LIMS procedures. (Note: All data can be archived to tape for subsequent restoration to meet contract requirements.) This product will serve to improve user response time and provide more LHDS database space. Initial implementations of this product have met with limited success. A procedure for secure, restorable data archiving is in development. Full scale implementation of this product will be accomplished in 1QFY93.

Upgrade to Structured Query Language (SQL) Software: SQL version 3.2 (upgrade) was acquired during the last quarter of FY92. This version of the database software was required to keep the LHDS current with existing systems, allow for continued IBM maintenance support, and provide for future upgrade of the database. SQL 3.2 is more efficient and will provide some improvement in user response time. However, installation of this product has been delayed because of the current high level of disk utilization. Disk storage must be remapped and reallocated to provide sufficient contiguous disk space to support the installation. Application of SQL version 3.2 is anticipated for 2QFY93.

The activities described above provided sufficient system capacity to allow continued normal operation of the LHDS during FY92, but do not provide a significant foundation for future growth. After implementation of the SAR product and upgrade to SQL 3.2, all known maintenance avenues for system capacity and performance enhancement will have been exhausted. Continued failure to provide hardware upgrades for LHDS in the form of a larger CPU and expanded disk capacity will significantly cripple future expansion of CILO and may result in a reduction of existing services as well. System performance and disk capacity remain the greatest challenge to CILO development.

Laboratory Information Management System

The Laboratory Information Management System (LIMS) continues to be the primary focus of LHDS operations. LIMS is a comprehensive database system that tracks all aspects of laboratory testing effort at MAF. LIMS is interfaced with various high volume lab customers and is capable of collecting, dispositioning, archiving, and reporting laboratory test data in a completely paperless environment.

CILO efforts on LIMS in FY92 were accomplished in three phases. First, several new LIMS procedures were developed to support expanded laboratory requirements. Second, over 1200 LIMS procedures were redesigned to maximize user interface advantages incorporated into VM-LIMS version 2.7.1. Finally, an extensive analysis of

LIMS capability to interface with concurrently developed automation initiatives was conducted and an implementation path analysis was initiated. A detailed discussion of each of these areas appears below.

Expanded LIMS Capability: LIMS capability was enhanced in two key areas. LIMS procedures for tracking and reporting Crimp Tool analyses were developed, tested, and implemented. Refinement of these procedures to enhance efficiency and capability continues as more variations of this complex analysis are requested. LIMS was also expanded to support high level job tracking and statusing for the Technology Operations group (Dept. 4351) of the Technology Laboratory. The required changes to LIMS provide the foundation for a centralized statusing vehicle for all laboratory work at MAF. Existing capability was developed and implemented in 4Q92. Refinement of LIMS procedures to track Technology Operations work will continue during FY93. The ultimate goal of this capability is to provide for automated job statusing and interface with global Technical Operations planning and control techniques.

Enhanced LIMS User Interface: The LIMS user interface was enhanced in two significant areas. First, procedures for submitting lab samples for Receiving Acceptance Plan (RAP) testing were streamlined and simplified. Second, necessary user interaction for multiple run data entry in the laboratory was reduced. These enhancements were realized as a result of the increased capability of version 2.7.1 of the VM-LIMS software discussed in the previous section. (Please refer to CILO involvement in the VM-LIMS User's Group later in this report for a discussion of Manned Space Systems involvement in VMLIMS enhancement.)

RAP sample submission procedures were enhanced by automating the test selection functions of LIMS. Previously, the burden of test and test element selection was placed on the lab customer when a LIMS submission was performed. Automation of these functions significantly reduced the number of screen operations (and decisions) the lab customer must make when performing a submission. Automation of test selection functions has eliminated the potential for erroneous selection of tests by the lab customer. This in turn has reduced the number of corrections necessary within the laboratory to perform work on submitted samples. A significant increase in the productivity of sample submission and subsequent laboratory handling of RAP submissions has resulted from this enhancement.

The improvement to lab data entry mentioned above has been realized as a result of version 2.7.1 of VM LIMS. Laboratory professionals now have the option to specify the number of analytical runs to perform in advance of data entry. The previous method did not allow pre-specification of runs and required the user to loop through several data entry screens for each run performed. The new method significantly reduces screen operations and thus enhances the productivity of multiple run data entry.

Interface With Concurrent Automation Systems: LIMS collects, reports, and archives laboratory test data for all aspects of ET laboratory analysis. This data currently supports various requirements of the laboratory and the laboratory's customers as specified by the ET contract and other contracts. Recently, planning and statusing of work in progress has become of interest to Manned Space Systems management and personnel. Projects such as MRPII/COPICS and Open Plan that endeavor to plan, control, and status work at MAF have developed concurrently with CILO/LIMS. Since LIMS provides the capability to status lab

work in progress, an investigation of the capability of LIMS to interact with these other automation initiatives was performed.

The investigation indicated that LIMS and COPICS (both IBM mainframe based software packages) were compatible. LIMS should be able to provide transfer of pertinent status data directly to COPICS as necessary. A LIMS/Open Plan interface is somewhat more involved. Analysis indicated that LIMS can be tailored to collect and track information required for open plan interface. Pertinent data points for tracking include:

- Open Plan Activity ID
- OBS and WBS Codes
- Work Center Associated with an Activity
- Status Technique
- Charge Number

LIMS updating to collect the necessary information for Open Plan interface is relatively trivial. Automating transfer of these data points and performing necessary advance calculations to support open plan style statusing, however, will require significant effort.

Interfacing LIMS with COPICS and Open Plan is possible and certainly a desirable enhancement to data automation at MAF. Automation initiatives of this type demand a multifaceted team approach to implementation. Since several databases external to the lab are involved, LIMS interface to COPICS and Open Plan is outside the scope of the CILO Project. Future progress in this arena will require the incorporation of CILO personnel into the project teams for COPICS and Open Plan.

Paperless Systems Development

Paperless systems are online (on screen) interactive applications that allow users to perform tasks without using paper. They are typically developed to enhance the productivity of an activity by eliminating paper based aspects of the activity and/or providing simultaneous multiple user access to the activity from multiple sites. Three categories of paperless systems were developed or enhanced during FY92. These categories are mainframe based systems, LAN based systems, and expert systems. A brief description of each category and examples of applications developed in each appears below.

Mainframe Based Paperless Systems: Mainframe based systems are applications developed and implemented on LHDS in support of laboratory users or laboratory customers. Typically, these systems are implemented on the mainframe to take advantage of resident mainframe software. Mainframe implementation may also be chosen to take advantage of the additional data security afforded by the LHDS environment (passwords, routine backups, etc). Two LHDS applications were developed, tested and fielded during FY92. These were Technology Laboratories Purchase Requisition Tracker and Technology Laboratories Budget Tracker.

PR Tracker: This application is an interactive database of all laboratory purchase requisitions (PR). The database is configured with a custom user interface for rapid data entry and retrieval. The application allows an authorized administrator to update information on any given laboratory PR. An authorized user can retrieve information about a given PR or set of PRs.

The database can be queried against any PR data desired. This facility is used by laboratory administrators and project personnel to track the progress of and expenditure on purchase requisitions. Figure 3 shows the user interface query panel for the PR Tracker application. This panel is typical of user interface panels developed for the mainframe prior to XMenu capability.

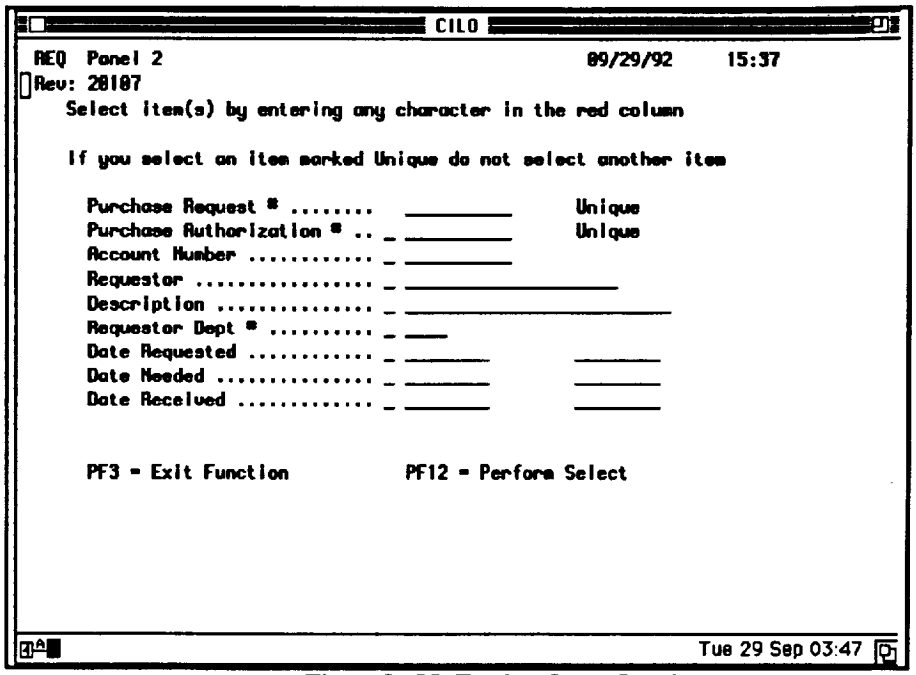

Figure 3. PR Tracker Query Panel

Budget Tracker: This application is an interactive database of laboratory cost management data. It is also configured with a custom user interface. The interface developed for Budget Tracker was recently upgraded using the XMenu software discussed in the mainframe performance enhancement section. This application allows an authorized administrator to input cost management data selected from various Technical Operations reports. An authorized user can then extract cost management data on a fiscal or calendar year basis (as appropriate to project type) and generate color graphics depicting performance to plan and year to date deviation from plan. This application has been used by laboratory management to track laboratory budget. Figure 4 shows a user interface panel created with XMenu software. Figure 5 shows a typical black & white representation of a color graphics chart generated by the budget tracking application.

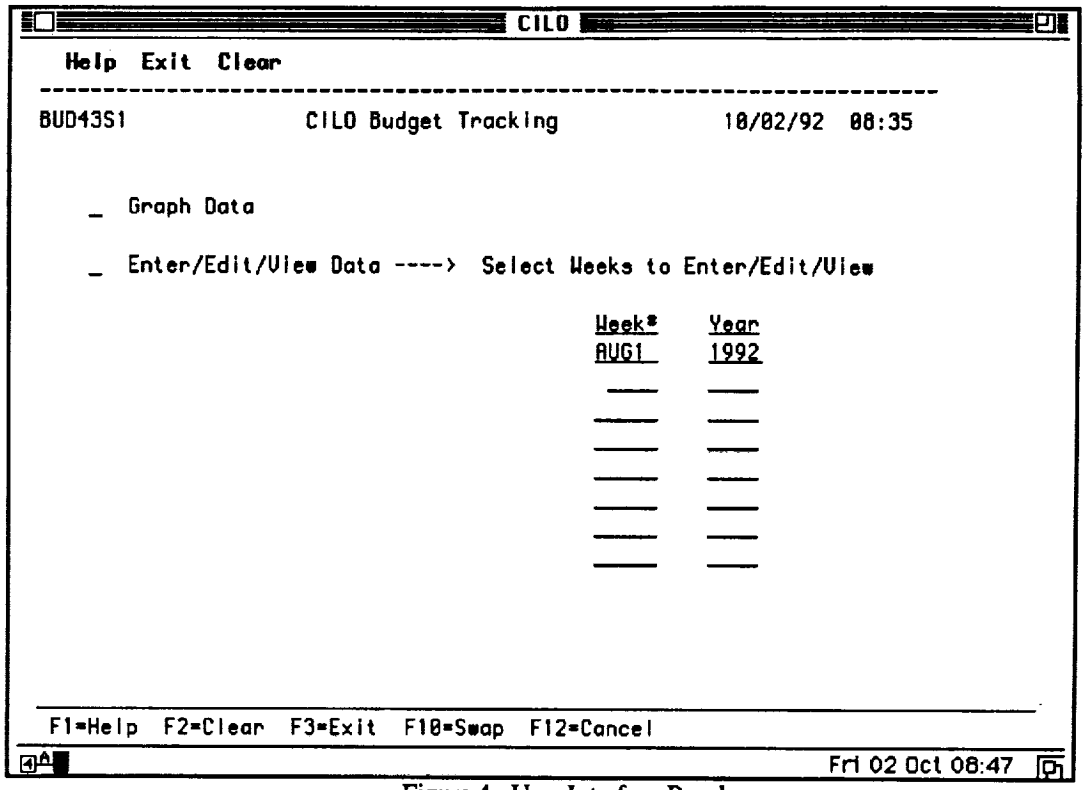

Figure 4. User Interface Panel

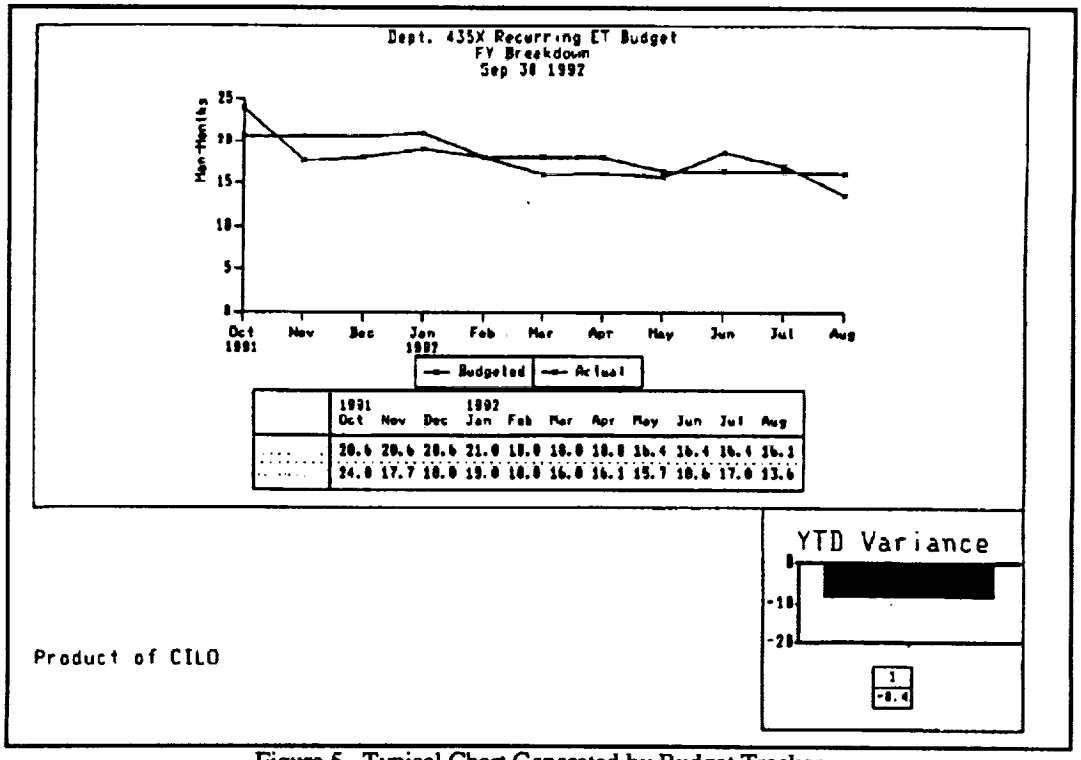

Figure 5. Typical Chart Generated by Budget Tracker

LAN Based Paperless Systems

LAN based systems are applications developed and fielded on microcomputers attached to MAF-LAN. These applications typically make use of the file server space allotted to Technology Laboratories and are developed using existing microcomputer software. Several LAN based applications were developed in support of laboratory requirements during FY92. These included a laboratory administrative support area, a laboratory action item tracker, a laboratory failure analysis tracker, and a laboratory document control facility. Development during FY92 was mainly focused on providing basic productive LAN capabilities for laboratory users. As a result most of these applications do not yet have a graphic user interface (GUI). The document control facility, however, is an advanced LAN based system with a sophisticated GUI. Development of a master LAN application control GUI is anticipated for FY93. Description of several LAN based paperless applications is provided below.

LAN Administrative Support Area: This area incorporates several administrative functions into a single application area. An authorized administrator is allowed access to update the various areas. Access is tailored by area and update areas are password protected. All MAF personnel have read only access to the lab administrative area. Features provided by the administrative area include:

- Lab Memo Logs and Lab Phone Number List
- Lab Authorized Signatures Matrix
- Lab Organization Chart

The administrative area is used by laboratory personnel to obtain routine office information. Figure 6 shows the online authorized signature matrix.

AUTHORIZED APPROVAL SIGNATURES - 435X

AUTHORIZED APPROVAL SIGNATURES	Time Cards	Overtime	Travel Authorization	Purchase Req. 1	RFF	Shipping Req.	Office Supplies	Paychecks	Library Req.	OVAR	Material Test Report	IPAD	Attendance Adj.	Material Request	LIMS Access 3	Labor Cost Corr.	ADPR Request	Zone 2 Entry	Prop. Removal Pass	ISSR 2	FAX			NOTES
4350																								1. In absence of Manager
Horak	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X				Only another Manager
Gaines							X	X		X						X					X			is authorized to sign
4351																								
Copeland	X	X				X		X		X		X	X			X	X	X						2. Only Tech Ops ADPR,
Nunez							X	X																Marvin Breslau is
Willick						X	X					X												Authorized to sign.
Davillier												X												
Larsen						X						X												3. Only LIMS System
Hanzlick								X																Administrator, John
McCutcheon												X												Spencer, may
Woringen												X												authorize.
4352																								
Hazelwood	X	X						X					X			X	X	X					
Spencer															X									
Benson							X																	
Catron							X					X												
4353																								
Fallon	X	X						X		X	X	X	X			X	X	X	X					
Fleming							X	X		X														
Brinker	X							X			X	X												* Pending
LeBoeuf	X					X					X	X												
Rando	X										X	X												
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Figure 6. Authorized Signatures Matrix

LAN Action Item Tracker: This area provides an action item tracking facility. An authorized administrator is allowed to add action items assigned by the manager and update progress on existing action items. All other MAF personnel are allowed read only access to the Action Item Tracker. This facility is used by laboratory management personnel to track and report on high priority assignments.

Failure Analysis Tracker: This area provides information on the status and disposition of laboratory failure analyses. This facility allows an authorized administrator to update information regarding new and existing failure analyses. Password protected read only access is granted to a limited number of users. This facility is used by Technology Laboratories and Advanced Technology management to track critical laboratory analyses.

Document Control Facility: The Document Control Facility (DCF) is an interactive, secure application for the generation, update, approval, and archival of laboratory documents such as Laboratory Instructions and Laboratory Practices. DCF currently utilizes a HyperCard based GUI interacting with MS Word application software and MAF-LAN. The DCF provides structured document control in a completely paperless environment. Development of DCF for the Macintosh platform was completed during 4QFY92. Successful implementation of this paperless technology has the potential to revolutionize document handling at MAF.

DCF technology can be transferred to larger, more diverse document handling environments. Features of the DCF include:

- Generation of new documents in a structured format
- Secure revision of existing documents
- Complete revision control with audit trail
- Secure, automated routing for approval
- Secure, paperless approval with audit trail
- Structured multiple level user access
- High level GUI with "push button" capability

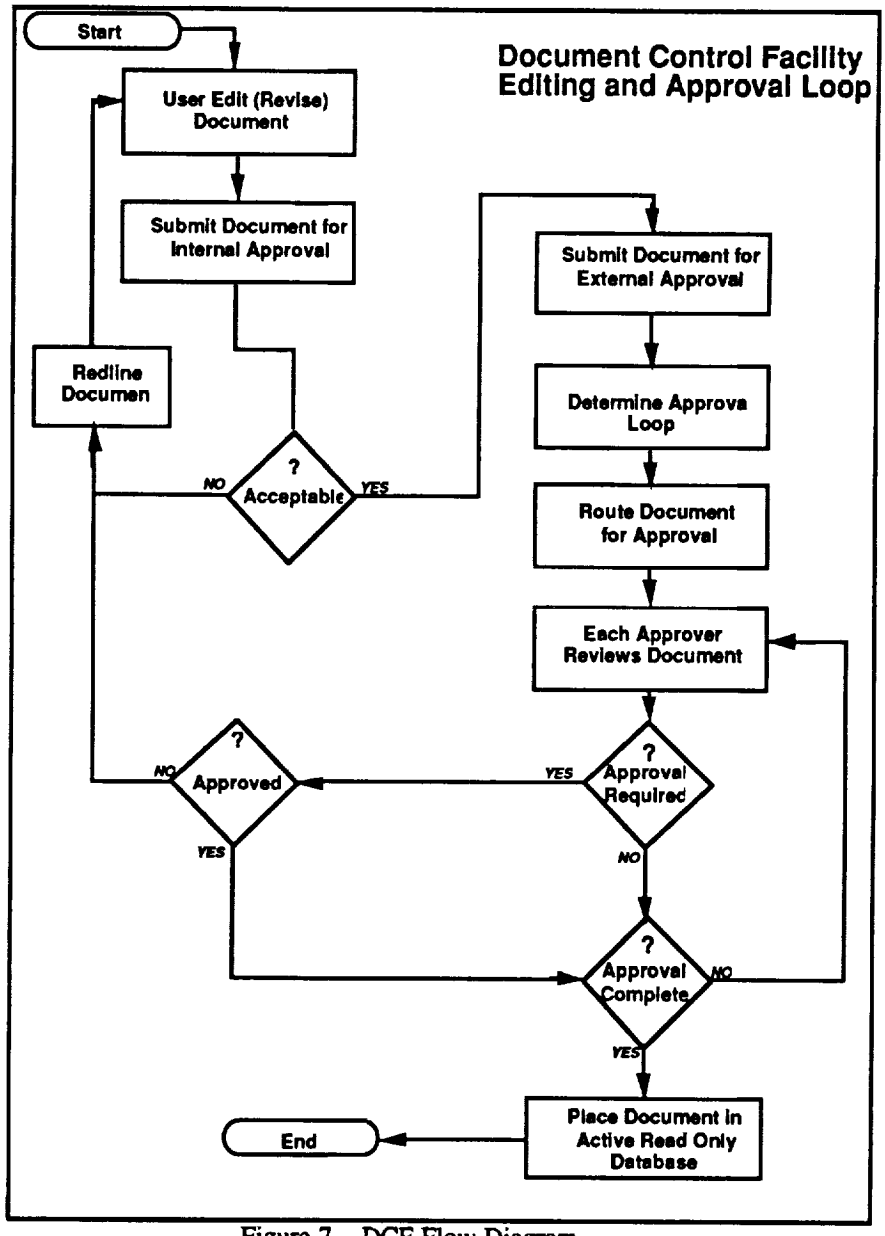

Figure 7. DCF Flow Diagram

The DCF allows an authorized user to generate (or revise) a laboratory document using a standard format. Once editing is completed, the DCF determines the correct approval signature loop for the document and routes

the document appropriately via LAN. Each authorized user in the identified approval loop may choose to approve the document, revise (redline) the document, or disregard the document. If the document is approved, a graphic of the approver's signature is attached with a date/time stamp and an approval log for the user is updated. If the document is revised, it is returned to the originator for editing and subsequently placed back into the appropriate approval loop. If the document is disregarded, a "Not Applicable" note is entered with the approver's signature and a date/time stamp is affixed. Once the iterative approval process is completed, the document is placed in a read only database on the LAN. Access to this database is limited to appropriate MAF personnel and is controlled through the DCF. Figure 7 provides a flow diagram of the DCF editing and approval function. Figure 8 shows the User Function Main Menu panel of the GUI for DCF; please note the "push button" interface features.

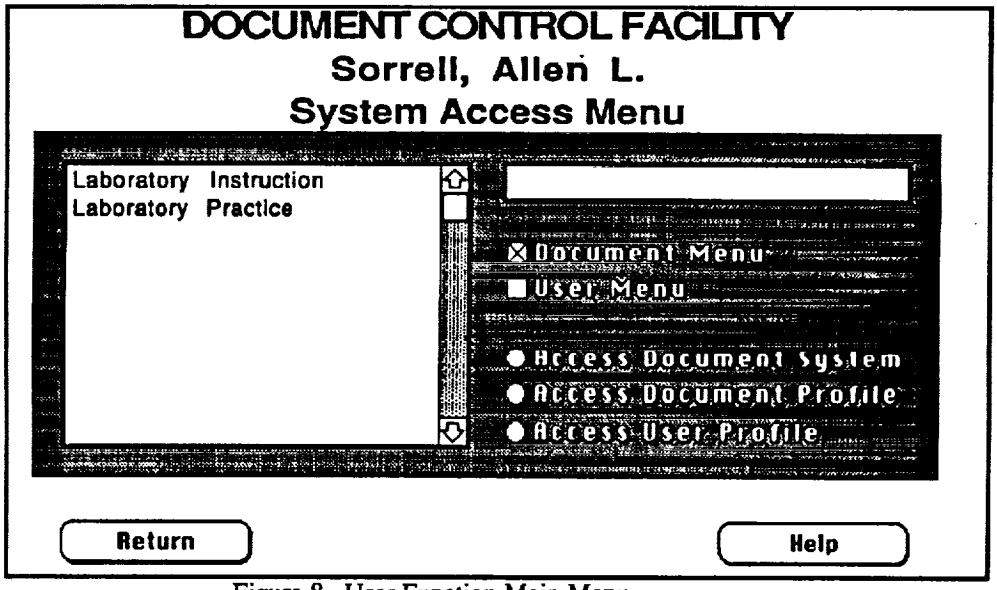

Figure 8. User Function Main Menu

DCF technology will be aggressively pursued during FY93. The application will be rigorously tested and improved on the Mac platform, ported to the DOS platform, and transferred to interested MAF groups. Improvement of DCF is scheduled for FY93 using the Technology Laboratories and various laboratory documents as a test bed. Improvements will focus on user interface and special document handling cases. DCF was developed exclusively for the Macintosh platform during FY92 due to a lack of comparable DOS based stack software at MAF. An analysis of stack based programming environments for DOS indicated that Spinnaker Plus would provide a suitable parallel to HyperCard on the Mac. Spinnaker was ordered and received during 4QFY92. Extensive testing of Spinnaker Plus will begin during 1QFY93. Upon completion of testing DCF will be ported to the DOS platform during FY93 using the recently purchased Spinnaker product. Implementation on the DOS platform will significantly enhance the utility of document control technology at MAF. Significant interest in paperless document control has been identified in various MAF organizations. The completely tested DCF product will be demonstrated to interested groups. Further development of this technology to support MAF organizations is anticipated.

Expert System ASK-ANDY

Expert systems are a special category of application software that seek to capture and maintain critical knowledge in a paperless environment. One such system, ASK-ANDY (formerly ESK-ANDY), was designed in the past to capture critical knowledge of the procedures involved in laboratory planning and control.

Lab planning and control requires knowledge of a large, diverse set of policies and procedures. Additionally, many nuances of planning and control can only be gained with significant experience. Knowledge maintenance in this area became even more critical during FY92 as a result of the loss of expertise due to retirement. This event left a single lab coordinator to support the requirements of over 70 lab professionals. As a result ASK-ANDY capability was expanded and improved to capture and maintain critical knowledge in the following areas:

- LOX Impact job planning and control
- Cryoflex job planning and control
- Purchase Requisition handling

The new version of ASK-ANDY provides enhanced support for lab requirements. It provides expert support of many complex planning and control tasks. It can be used to guide a novice lab planner through complex tasks in the absence of the Planning Lead. Finally, this application can be used to cross-train personnel in lab planning techniques.

ASK-ANDY development is an evolutionary process. Activities planned for FY93 include capture of crimp tool planning and testing knowledge and development of application based expertise in Request to Manufacture processing for heat treatment of samples for lab testing.

Automated Systems Development

Automated systems are special projects undertaken to implement automation technology in support of MAF requirements. One such system is the Weld Acceptance Data Evaluation System (WADES). WADES is a computerized, paperless system that will automate the collection of data gathered from the quality inspection of welds and the evaluation of this data to determine the acceptability of welds on the ET vehicle.

Extensive CILO team effort was expended on WADES development activities during FY92. Efforts were concentrated on two major tasks including development of a portable data collection system and development of a workstation based intelligent data evaluation system. A brief description of each task appears below.

Portable Data Collection System: CILO personnel developed a portable data collection system for use throughout the weld inspection process. The system was implemented on a lightweight tablet-computer equipped with light pen technology. The tablet computer is capable of capturing data from measuring instruments via standard computer communications interfaces. Light pen technology provides the capability to capture subjective data via a "hand written" interface. Forms typically used for this purpose have been recreated on the tablet-computer. Weld inspectors can write data directly on the tablet computer screen using the light pen. The system is equipped with character recognition software that translates the hand written input into typed text for maximized readability. This interface is tremendously ergonomic, will require limited training, and minimizes re-

sistance to change. Figure 9 shows an example of a WADES portable collection system in use with the attached light pen.

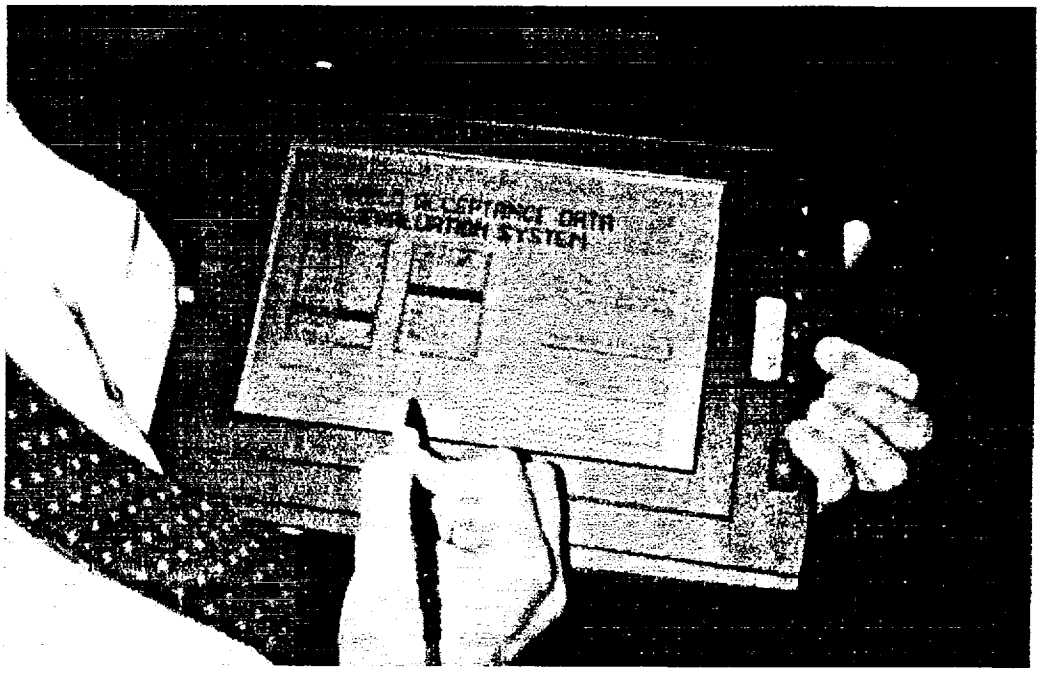

Figure 9. WADES Portable Data Collection System

The portable system developed will vastly improve the weld data collection process. The current process is labor intensive in data handling. Many redundant manual transcriptions of data are necessary. The portable system will be carried by inspectors to each of the various data collection points for a given weld. Data will be captured electronically or entered via light pen as appropriate to the data collection process. The portable unit will be returned to a central DOS workstation and the collected data will be transferred to a master database and evaluated using the intelligent evaluation system discussed below. The new process will eliminate the need to manually transcribe weld acceptance data, improve quality of data reporting and evaluation, and enhance the productivity of the weld data collection process.

Development of this technology was 90 percent completed during FY92. Development of the data transfer capability will be completed during 1QFY93. Floor testing will also begin during 1QFY93. The collection system will be enhanced as necessary to meet the needs of the customer as identified during the testing phase and subsequently implemented.

Intelligent Data Evaluation System: CILO personnel began development of a secure, automated data evaluation system for weld acceptance data during FY92. This interactive evaluation system incorporates a secure database, data import capability, and an intelligent data evaluation expert system. The evaluation system is capable of receiving weld data from the portable collection system, identifying the weld analysis to be performed, isolating the correct specification, measuring weld compliance using appropriate data parameters, and dispositioning the weld data. The system is also capable of recording weld retest and rework process information. The system delivers a formatted weld report to the weld inspector

upon completion of each weld analysis cycle and secure archiving of completed weld data is subsequently accomplished.

The new evaluation system will vastly improve the analysis and disposition of weld data. The existing process requires tedious manual verification of weld parameters versus complex specification combinations (specification parameters for this analysis must be modeled in four dimensional space). Manual recording of weld dispositions, and secure storage of reams of completed weld reports are also required. The WADES evaluation system will automate the analysis and disposition of weld data. Manual reporting methods will be eliminated. Secure archiving will be accomplished electronically. The new system will result in enhanced quality and productivity for weld acceptance evaluation.

During FY92 the weld evaluation system module for circumferential ET welds was completed. During 1QFY93 the security routines will be added to the system and the circumferential weld module will be field tested, revised as necessary, and implemented. Additionally, the non-circumferential weld module will be developed, tested, and implemented.

Hardware Improvements

Two significant improvements to the LHDS hardware configuration were accomplished in FY92. First, a combination power conditioner and battery backup system was acquired and installed in 4Q92 to support the LHDS. Second, twelve DOS workstations were received and installed in laboratory areas. A brief description of each activity appears below.

Power Backup System: The power backup system was identified as an LHDS requirement in FY89. Power conditioning and battery backup is required to prevent hardware damage as a result of plant power fluctuations and maintain data integrity in the event of power loss. A power backup system was requested in FY89.

In 4Q92 a power conditioner battery backup system was received and installed in support of the LHDS. The system acquired provides constant clean power to LHDS. In the event of power loss the system switches automatically to battery backup. The battery system will provide sufficient time to perform an orderly shutdown of the LHDS.

Installation of the power backup system provides significant protection for LHDS hardware from the plant environment. Additionally, the orderly shutdown capability significantly reduces the potential for data corruption or data loss due to power failure. Implementation of this system significantly enhanced the quality and reliability of LHDS support to ET processes.

Microcomputer Workstations: As a result of the CAP initiative, twelve microcomputer workstations were installed in laboratory areas during FY92. Many of these units are LAN connected. These new workstations are tremendously beneficial to the CILO Project.

The new LAN connected DOS workstations were configured for communication with LHDS. This effectively increases LHDS terminals by six units during FY92 at no cost to the CILO project. Figure 10 shows LHDS connected equipment growth including these new units. The new units will be configured with

Spinnaker Plus run-time productivity applications to support laboratory requirements in FY93. Additionally, these units significantly expand laboratory technical writing and presentation preparation capabilities. Implementation and interface of these new units has significantly enhanced laboratory productivity.

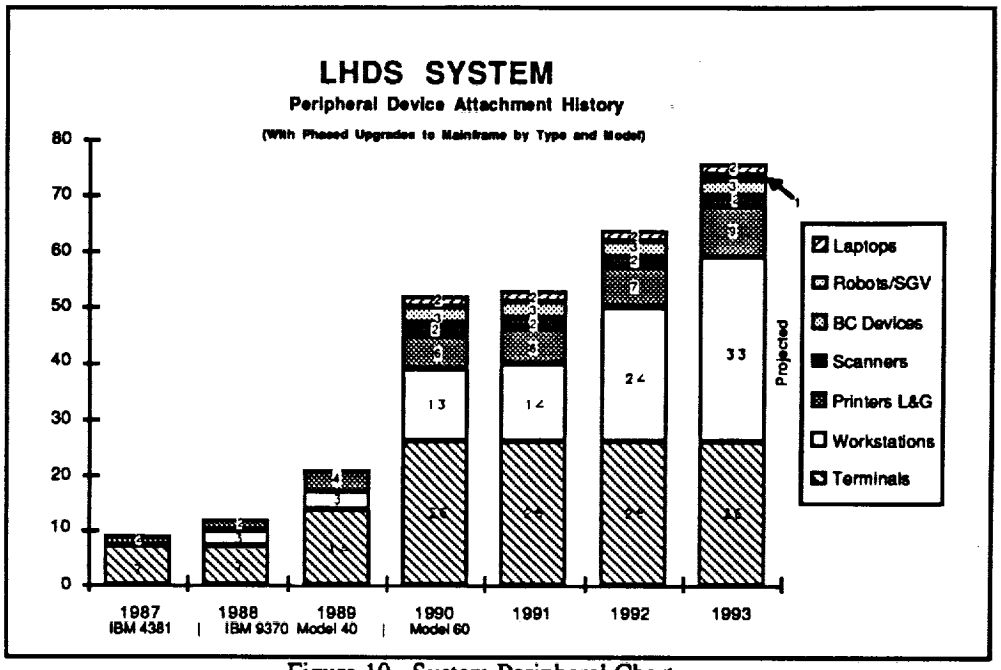

Figure 10. System Peripheral Chart

Related Automation Activities

CILO team personnel participated in two significant automation technology related activities during FY92. CILO personnel conducted a one day seminar on aspects of paperless technology development and implementation for NASA and contractor personnel. CILO personnel also participated in an international VM-LIMS forum. Both activities served to expand the use of automation technology and shape the future of paperless system growth at MAF. A brief description of each activity is provided below.

Automation Technology Seminar: The Work Authorization Tracking System (WATS) team is responsible for developing and implementing a paperless system for test stand work authorization in the West Test Area at Marshall Space Flight Center (MSFC). The WATS team invited CILO team personnel to visit MSFC and review their efforts to develop paperless technology. Additionally, WATS personnel requested a one day seminar on paperless automation development and accomplishments at MAF.

Accordingly, CILO personnel traveled to MSFC and reviewed WATS efforts and development plans. Several suggestions were provided for expansion and enhancement of WATS capability. Locally, a plant tour and automation seminar was coordinated and delivered to the WATS team by CILO personnel at MAF in 3Q92. Major topics addressed during the seminar included:

- LIMS Overview
- WADES Overview

- Portable Paperless System Hardware
- Expert System Demonstration
- Automation Project Lessons Learned
- Round Table Discussion of Paperless System Development

Response to both activities was favorable. The CILO Project Team has been established as an authority in the development, implementation, and application of paperless systems and automation technology in technical arenas. Future interaction with the customer in these areas is anticipated.

VM-LIMS Forum: CILO team personnel represented Manned Space Systems in the International VM-LIMS User's Group. This organization is made up of laboratory data processing professionals from a broad spectrum of technical applications in the United States and Europe. The User's Group provides a foundation for the exchange of ideas between the vendor, Axiom Systems Group, and other LIMS professionals. The CILO Project Lead served as President of the User's Group during FY91 and FY92.

Participation in the User's Group afforded the opportunity to specify required product enhancements and direct the future of the VM-LIMS product. Several of the enhancements provided in VM-LIMS version 2.7.1 (and the increased productivity realized by implementing them) were the direct result of interaction with the User's Group. Several new enhancements identified as user's group requirements at the last meeting are expected in the next release of the VM-LIMS product. Additionally, many useful ideas and techniques applicable to the Manned Space Systems implementation of VM-LIMS were obtained from interaction with other members of the User's Group.

V. CRITICAL ISSUES

Several critical challenges face the CILO Project Team. Future development of automation technology in the Technology Laboratories and MAF at large depend on successful resolution to these critical issues. A few of these issues are briefly presented below.

Commitment to Development: The development of automation technology requires consistent commitment to project goals by all employees. CILO and other automation projects have suffered significant difficulty in obtaining the necessary support to meet identified project requirements. This has been especially evident in the consistent inability to upgrade the LHDS CPU and add direct access storage devices (DASD - system capacity) over the past three years. Failure to upgrade has resulted in deferal of automation initiatives, inability to maximize productivity, and a reduced ability to meet customer needs through automation.

In order to realize the full potential afforded by automation technology, a concerted effort of project personnel, management, and the customer is imperative.

Project Matrix Team Skill Mix: The CILO Project Team consists of a variety of technical professionals encompassing disciplines such as chemistry, computing, measurement science, application development, and hardware communications. The current project environment also requires considerable planning and control experience that is not adequately provided by current team members.

Funding for a skilled technical planner is required to provide necessary guidance in the development and implementation of team goals and to provide improved cohesion between team members and activities.

Project Selection and Implementation Philosophy: In the past, CILO project goals have been selected and implemented to provide a foundation for paperless technology and automation with only moderate emphasis placed on return on investment (ROI). This approach typically resulted in large multi-phased projects requiring long term effort. Although significant ROI has been realized, it has not been maximized. At this time the desired foundation is nearly completed.

The ET contract environment now demands increased productivity and reduced cost with fewer personnel and the prospect of higher production rates. Judicious implementation of automation technology will make this environment attainable. However, long term tasks requiring significant expenditure of labor and funds will be increasingly difficult to successfully implement in this environment.

A fundamental change in the CILO approach to automation tasks is required. Future tasks will be selected and implemented on the basis of an improved ability to meet contract requirements and graded potential for successful implementation. Future CILO tasks will exhibit the following characteristics:

- High Potential for Productivity Enhancement
- High Potential for Successful Implementation
- Short Term Development Cycle
- Committed Customer Support

VI. VIEW TO THE FUTURE

Automation technology will become increasingly important over the next several years. Progressive implementation of paperless systems and streamlined, automated processes will improve Manned Spaces Systems' ability to meet the difficult challenge of providing affordable high quality space systems. The CILO Project Team is capable of developing and implementing a wide variety of such systems in the operations and technical environments. Accordingly, CILO personnel will continue to expand existing laboratory capabilities, provide support to new and ongoing automation initiatives at MAF, and continue with efforts to transfer successfully implemented technology. An outline of future activities appears below.

Laboratory Systems

CILO personnel will continue to build on the foundation of automation techniques implemented to date in support of the laboratory. Once again, major emphasis will be placed on upgrade of the LHDS through hardware and software improvement. Additional effort will be focused on LIMS activities. Specific goals for FY92 are listed below.

- Expand LIMS support to include VAB lab customers
- Implement reporting of RAP data via LIMS
- Implement rapid access user interface upon receipt of necessary materials
- Continue ongoing LIMS user interface improvement
- Apply the SAR product to LIMS

LAN based laboratory user support applications will be expanded and improved. Emphasis in this arena will be to maximize operations information flow among lab professionals and management. Specific activities planned are listed below.

- Expand and improve Document Control Facility
- Identify, develop, and implement new productivity applications
- Develop and implement Laboratory Master LAN GUI
- Develop and implement DOS print service capability

The laboratory planning and control expert system, ASK-ANDY, will be expanded and enhanced to provide better support and cross training capability for laboratory expertise in the planning office. Specific activities will focus on knowledge in the areas listed below.

- Crimp tool planning, preparation, and testing
- Request to Manufacture preparation and handling for laboratory heat treatment requirements

CILO personnel will promote LIMS as a data source for other MAF automated data systems including COPICS and Open Plan. Implementation paths will be identified and reported. Necessary matrix team activities will be initiated.

Automated Systems

Automated systems development will consist of two phases. The WADES project will be completed and implemented and at least one new automation initiative will be selected and implemented.

WADES activities will include:

- Completion of portable data system data transfer capability
- Completion of security modules for the intelligent data evaluation system
- Development and implementation of the non-circumferential weld analysis module

The new automation initiative will be selected on the basis of criteria outlined in the critical issues section above. An analysis of need for automation technology was conducted during FY92 to obtain a list of potential candidates and customers. Several of the identified candidates are listed below.

- Automated Processing of Receiving Documents
- Automated R&I Record Maintenance/Archival
- Automated On-Site Calibrations
- Automated Weld Data Acquisition - WADES Phase II

Technology Transfer

CILO personnel will continue to support the development of automation technology at the request of the customer. Additionally, export of technology developed as part of the CILO project to other Martin Marietta Manned Space Systems and Martin Marietta Corporation organizations will be pursued. Significant interest in the DCF technology has been identified. Demonstrations of capability and transfer of this technology to other Technical Operations and MAF groups is anticipated for FY93.

VII. CONCLUSIONS

The CILO Project Matrix Team has worked diligently to identify, develop, and implement automation technology at MAF and to support the development of paperless systems at MSFC. Benefits at MAF directly attributable to these efforts include significantly enhanced laboratory capability; implementation of automated data evaluation, disposition, and reporting systems; significantly enhanced quality, reliability, and productivity of laboratory data handling processes; an expanded foundation for TQM initiative implementation; and an improved posture to meet the challenges of the future. Additionally, CILO efforts have resulted in the development of automated document handling techniques that will revolutionize document control at MAF and significantly increase document handling productivity.

The changing ET manufacturing environment requires increased productivity with fewer resources. This environment demands successful implementation of automation technology to meet project requirements. CILO efforts to date have provided a good foundation for future advancements in automation technology in the Technology Laboratories and other MAF organizations. However, many potential high ROI applications remain to be developed and implemented. The CILO Project Team provides the necessary training, experience, and ability to identify, develop, and implement these important applications.

Glossary of Terms and Definitions

AI. Artificial Intelligence

Archival. Data preserved in its original state for a long period of time. The definition of length is flexible— anywhere from five to more than 100 years— depending on the storage medium.

ASK ANDY. Expert System application.

Back-Up. A copy of stored data. A fixed magnetic disk, for example, can fail—and accidentally destroy the data it contains. A back-up prevents catastrophic loss of valuable information.

CAP. Computer Aided Productivity

CILO. Computer Integrated Laboratory Operations

CPU. Central Processing Unit

DASD. (See Direct Access Storage Device)

Database. A collection of information. The computerized method of collecting, organizing and manipulating information is called a Database Management System.

Direct Access Storage Device (DASD). A storage peripheral, usually a disk drive, which can respond directly to random requests for information.

DOS. Disk Operating System.

ES. Expert Systems.

GUI. Graphical User Interface.

LAN. Local Area Network. A network of connected devices within a small area such as a single office, group of offices, or building.

LI. Laboratory Instructions.

LIMS. Laboratory Information Management System

LHDS. Laboratory Host Data System

LP. Laboratory Practice.

MAF. Michoud Assembly Facility

Minimainframe. A large and powerful computer used for centralized applications like LIMS.

MIS. Management Information Systems

MRP. Manufacturing Resource Planning

MSFC. Marshall Space Flight Center

Open Plan. Work planning and scheduling software program

Peripheral. Any device which attaches to a computer. For example: CRT terminal, printer, disk drive.

PC. Personal Computer

PR. Purchase Requisition

RAP. Receiving Acceptance Plan

SAR Selective Archiving and Retrieval software product from Axiom Systems Group. Provides secure archiving and retrieval of laboratory test data stored in LIMS.

SGV. Self Guided Vehicle

SQL. Structured Query Language.

Storage. The capability of a computer, for example, to hold data.

VM. Virtual Machine

VM-LIMS. Database Software

WADES. Weld Acceptance Data Evaluation System

Workstation. Configuration of computer equipment designed for use by one person at a time.

XMENU. User interface screen handling software.

ADDENDUM TO ANNUAL REPORT

DUE TO A REALIGNMENT OF PRIORITIES, BUDGET FOR THE CILO PROJECT HAS BEEN REDUCED TO A LEVEL OF FUNDING SUFFICIENT ONLY TO SUPPORT MINIMAL MAINTENANCE OF EXISTING APPLICATIONS. UNTIL ALTERNATE SOURCES OF FUNDING ARE IDENTIFIED, NONE OF THE DEVELOPMENT ACTIVITIES IDENTIFIED IN THIS REPORT CAN BE INITIATED, NO TECHNOLOGY TRANSFER OF CILO DEVELOPED APPLICATIONS ARE POSSIBLE, AND INTERFACE OF LIMS TO OTHER AUTOMATION PROJECTS MUST BE ABORTED.

THIS WILL BE THE FINAL REPORT ON THIS PROJECT.